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Diagnostics of basal conditions - the formation of extensive zones of surface ribs in ice-sheets and streams

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Most if not all current predictions of the evolution of ice-streams to changes induced by global change assume static basal conditions. This is a result of current restrictions in the remote sensing of the ice-sheet basal physical environment, which cannot resolve the small-scale phenomena believed to control the basal traction. The search therefore is on for observable structures or features that are the result of the operation of basal processes. Any successful theory of ice-sheet basal processes would need to be able to explain such phenomena associated with or caused by special properties of the basal environment. We present one class of these phenomena, and also present tentative hypotheses as to their formation.

Using recent high-resolution observations of the Antarctic and Greenland ice sheets topography, the computed driving stress and the inferred basal traction reveal broad-scale organization in 5–20 km band-like patterns in both quantities. The similarity of patterns on the Greenland and Antarctic ice sheets suggests that the flow of ice sheets is controlled by the same fundamental processes operating at their base, which control ice sheet sliding and are highly variable on relatively short spatial and temporal scales. The formation mechanism for these bands contains information about the operation of the sub-glacial system.

There are three possible, non-exclusive causes of these ribs which we examine from a theoretical and evidential point-of-view
(i) They are the surface response to similar bands in the basal topography, whose regularity would equally require an explanation in terms of basal processes.
(ii) They are translating surface waves in the ice, supported by membrane stress gradients rather than by gradients in the basal resistance.
(iii) The ribs are due to the development of a band-like structure in the basal shear stress distribution that is the result of a pattern-forming instability in sub-glacial till and water flow, perhaps related to the formation of sub-glacial landforms.